Where Would CINDI Be?
A 3-D Scale Model of the Earth-Moon System

With guidance from the teacher and working in small groups, students will build a scale model of the Earth-Moon system, predict the Earth-Moon distance on their model, the distance of Earth-orbiting spacecraft, and the upper limit of Earth's atmosphere.

Purpose: to aid students in understanding the scale of the Earth-Moon system and the Earth's atmosphere within that system.

Texas Essential Knowledge and Skills (TEKS) for Science (http://www.tea.state.tx.us/rules/tac/chapter112/index.html):
6.2, 6.3, 6.4, 6.5, 6.13
7.2, 7.3, 7.13.B
8.10.B, 8.13A;B;C
IPC: 2.

Materials Required
- 1/2 standard container of child's play dough for each group of 2 to 4 students.
- 1 metric ruler per group of students
- 1 worksheet per student or group of students
- 1 calculator per group of students
- 1 meter stick or tape measure per group of students (optional)

Time required: One class period

Part 1

1. Divide the class into small groups of 2 to 4 students. Give each group of students a half a standard-sized container of Play Doh ™ or other similar product.

2. Ask each group to divide it into 50 roughly equal parts (for younger students, this can be a worth-while math problem by itself). Encourage them to think about possible ways to divide the dough, and to work as a group.

3. Ask each group to choose one piece of "average" in size, roll it into a ball, and then set it aside.

Note this next step can be frustrating, but the learning is worth it

4. Next ask each group to combine the other 49 pieces back into a large ball. (Explain that you have a good reason for asking them to do this, but don't expect your students to like it.)

5. When cries of protest have died down, explain that the students have just created a scale model in size of the Earth – Moon system. The Earth has 49 times the volume of the Moon.

Note: Students will recognize that it takes 49 Moons to fill 1 Earth; they just did it. Likewise, if Earth and Moon were made of the same stuff, their mass would follow this ratio. (Actually, the Moon has at best a very small iron core, and the bulk of it is composed of a material similar to Earth's lower-density mantle, so the Earth is about 80 times the Moons mass).

6. Have each group measure and record the diameters of their two balls.

7. Now ask each group to create a ratio of the diameters of their "Earth" and "Moon" balls. The "Earth" should be a bit less that 4 times the diameter of the Moon (about 3.7 times would be closer to the real Earth-Moon system.)

8. Ask the students how far apart their model Earth and Moon should be if we use the use the same scale for distance as we do for size. (Imagine we could shrink the entire Earth-Moon system down to the size of our play dough balls.)

Most students will predict the Earth and the Moon to be close together, with only a few Earth diameters between them.

Part 2

1) Have each student group begin filling out a chart and fill in the answers comparing their model Earth and the Moon.

Table 1: Properties of the Earth-Moon Model

Property	Earth	Moon
Volume in "Moon" units	49 "Moons"	1 "Moon"
Actual Diameters	*5.5 cm**	*1.5 cm**
Diameters in "Moon" units	3.7 "Moons"	1 "Moon"
"Earth-Moon" Distance	30 Earths	110 Moons
"Earth-Moon" Distance in cm	165.0 cm	

* Actual values of diameters and their ratios will vary quite a bit for several reasons. As long as student numbers are reasonable, they should be accepted. Students should not expect to get an "exact" answer.

2) Next, have students measure out the appropriate distance between their "Earth" and "Moon", and either hold them out at that distance, or place them on their desks/table at the appropriate spacing. The distance should be about the distance between two hands outstretched on either side of the body, or a little bit greater.

3) Now ask students to predict where an orbiting spacecraft such as C/NOFS (CINDI), the space shuttle, or the space station would be if added to the model. Where would the "top" of the atmosphere be?

Part 3 – Real Distances and the Earth's Atmosphere

Table 2: Real Distances and Sizes

Property	
Real Earth Diameter	12,734 km
Real Moon Diameter	3,476 km
Real Earth-Moon Distance	384,000 km
Average Orbit of the International Space Station (ISS)	385 km
Average Orbit of the C/NOFS satellite with CINDI	563 km
Height of the "Top" of the Atmosphere above Sea Level	About 2000 km

Have students look at the table above with real distances and sizes, and compare those numbers to their model, and then answer the following questions on their worksheet:

1) How does the ratio of the real Earth and Moon compare with your model "Earth" and "Moon"?

2) How far should the International Space Station (ISS) be from the "Earth" on your model? (Hint: Divide the height of the ISS by the real diameter of the Earth. Then multiple by the diameter of your model Earth to get distance the ISS would be on your model.) Find that place on your Earth-Moon model.

3) How far away should a model NASA/Air Force ionospheric experiment, CINDI, be from the model Earth? Find that place on your Earth-Moon model.

4) How far away would the "top" of the Earth's atmosphere be on your model? Find that place on your Earth-Moon model.

When each group has had a chance to answer the questions on their worksheet, discuss their findings as a class. Ask groups to show you how far the International Space Station, CINDI, and the top of the atmosphere would be on their model. Finally, discuss what results the students found most surprising!

(When done with the dough, make sure the students place it back into the containers and close the lids tightly!)

Extension: Combine with the *How High is Space?* atmosphere scale model:

1) How many sheets of paper are in your model of the Earth's atmosphere?
2) The Moon is about 384,000 km from the Earth. How many sheets of paper would you need to add the Moon to your atmospheric model?
3) The Earth has a diameter of 12,756 km. How many sheets of paper would you need to add the size of the Earth to your scale model?
4) The Moon has a diameter of 3476 km. How many sheets of paper would you need to include the size of the Moon to scale on your model?

Note: You can use this Earth-Moon model for other purposes, too, including the teaching of eclipses. Have a bright light bulb or even your overhead projector on in a dark room. Have students try to cast shadows on their model Earth with the model Moon and vise versa. (You can use toothpicks as handles for your dough balls.) It's not a easy thing to do at all. Your students will probably want to bring their model Earth and Moon close together, which means they are no longer in scale in distance. This exercise can help reinforce an understanding of why lunar eclipses are relatively rare, and why solar eclipses (Moon's shadow on the Earth) are even more rare. The Earth, Moon, and Sun must be aligned just right for either type of eclipse to occur, and the larger Earth produces a much bigger shadow than does the Moon.

Name______________________________ Date___________ Period______

The Earth and the Moon Model

"How big is the Moon? How far away is it? How far away are spacecraft that orbit the Earth?

Procedure: Listen to directions from the teacher and answer the following questions.

Part 2

1) You have created a replica of the ___________ and the ____________.

2) How many moons would it take to fill 1 Earth? ___________

3) Predict the ratio of the Earth's diameter to that of the Moon: __________

4) Using the metric ruler measure the diameter of the Earth and Moon.

    a. Earth's diameter__________ Moon's diameter ___________

5) Divide the Earth's diameter by that of the Moon _________.

6) If the Earth and Moon were really the size of their clay balls, how far apart would they need to be?

Fill in **Table 1: Properties of the Earth-Moon Model**

Property	Earth	Moon
Volume in "Moon" units		1
Actual Diameters		
Diameters in "Moon" units		1
"Earth-Moon" Distance	30 Earths	110 Moons

“Earth-Moon” Distance in cm	

Part 2:

Table 2: Real Distances and Sizes

Property	
Real Earth Diameter	12,734 km
Real Moon Diameter	3,476 km
Real Earth-Moon Distance	384,000 km
Average Orbit of the International Space Station (ISS)	390 km
Average Orbit of the C/NOFS satellite with CINDI	563 km
Height of the “Top” of the Atmosphere above Sea Level	About 2000 km

Using Table 2 above answer the following questions:

1) How does the ratio of the real Earth and Moon compare with your model “Earth” and “Moon”?

2) How far should the International Space Station (ISS) be from the “Earth” on your model? (Hint: Divide the height of the ISS by the real diameter of the Earth. Then multiple by the diameter of your model Earth to get distance the ISS would be on your model.) Find that place on your Earth-Moon model.

3) How far away should a model NASA/Air Force ionospheric experiment, CINDI, be from the model Earth? Find that place on your Earth-Moon model.

4) How far away would the “top” of the Earth’s atmosphere be on your model? Find that place on your Earth-Moon model.

Note: Lab group must all agree on how far apart their Earth and Moon needs to be! Use a metric ruler or meter stick to measure distance apart.